THE CHANNEL TUNNEL.

BY J. CLARKE HAWKSHAW, C.E., M.A., F.G.S.

[Read before the Mechanical Section of the British Association Meeting at Southampton.]

This year the Channel Tunnel Company sought to obtain powers from Parliament to enable it to make a tunnel to connect this country with France by a railway beneath the Channel, and it deposited plans and prepared a bill for the purpose. The Southeastern Railway Company did likewise. Neither company obtained a hearing before Parliament; but there have been preliminary inquiries by the government, the results of which are that they have announced their intention of submitting the whole question to a select committee of both Houses, to be appointed early in the next session of Parliament. The Channel Tunnel Co. had proposed to make a tunnel beginning in Dover and passing beneath the shore line, about two miles eastward of that town, at Fan Hole, near the South Foreland. The Southeastern Railway Co.'s plans showed a tunnel beginning at the west end of the under cliff, which lies between Folkstone and Abbott's Cliff, and which was to pass beneath the shore line near Shakespeare Cliff to the west of Dover.

A Submarine Continental Railway Company was incorporated this year to purchase certain works belonging to the Southeastern Railway, consisting of two shafts sunk on the foreshore near Abbot's Cliff and Shakespeare's Cliff in the lower beds of the chalk and a mile or thereabouts of headings driven in the lower beds of the same formation.

The Channel Tunnel Company was incorporated ten years ago—in January, 1872—when it had already existed in the less ambitious form of a committee for four years, and it comprises among its supporters and advisers those who nearly 17 years ago carried out the first practical investigations, both geological and engineering, which were undertaken with the view to ascertain where and how a tunnel could be made underneath the Channel. Geological surveys were then made which determined the identity of the beds on the two sides of the Channel. The continuity of the same beds across the bottom of the Channel was determined by a sounding apparatus which brought up specimens from the bottom. The thickness of the chalk was obtained by borings 500 ft. deep made through it on the two coasts, and a machine made by Mr. Burnton for excavating chalk was tested and was found to work as rapidly and as efficiently as the machine lately used between Folkestone and Dover, of which so much has been said. All the geological work was done in the years 1855-67. The machine was tested in 1870.

Monsieur Thomède Gamoud was the first engineer who worked at the geological part of the question. He proposed in 1866 to make a tunnel under the Varne from Folkstone to Cape Gris Nez through the Wealden and Oolitic formations.

For some years before this time Sir John Hawkshaw had been considering the practicability of a tunnel under the Channel, and early in 1865 he obtained the services of Mr. Day, an accomplished geologist, and who spent several months in that year in examining and surveying the cretaceous and underlying beds on the English and French coasts.

To supplement Mr. Day's work, in so far as it related to the Channel, Sir John Hawkshaw employed Mr. H. M, Brunel to take soundings across the Channel. and to ascertain, as far as possible, the nature of the material forming the bottom of the sea. An apparatus was devised for the purpose, by means of which specimens of the sea bed were obtained. It was found that instead of the sea bottom being composed of loose, transported material, it was mostly formed of rocks, *in situ*, similar to those seen on the adjoining coasts.

This marine survey carried out in 1865, 1866, determined the continuity of the upper cretaceous beds across the Channel. It was still necessary to ascertain whether the thickness of the lower beds of chalk which had been measured in the cliffs on both coasts where all the beds are exposed was maintained after the lower beds disappeared beneath the sea. Accordingly, Sir John Hawkshaw determined to bore through the chalk at two points on the English and French coasts respectively. In this costly operation he was assisted by the late Mr. Brassy, Mr. Wythes and Mr. Easton. The points selected for the boring was St. Margaret's Bay in England, distant four miles east of Dover, and about eight miles east of the out-crop of the lowest chalk beds on the coast, and Ferme Mouron in France 2¼ miles east of Calais and four miles east of the out-crop of the same beds in the French coast. These borings showed that the thickness of the lower chalk does not diminish to any extent as we follow it eastward from the out-crop. In 1867 Sir John Hawkshaw prepared plans for the Anglo-French Committee in conjunction with Mr. Brunlees and M. Thomè de Gamoud, showing a tunnel from St. Margaret Bay in England to Ferme Mouron in France. In 1868 the Anglo-French Committee applied for a concession from the French government and a commission was appointed that year in France to examine the question. After various inquiries, and a long correspondence between the two governments, a concession was obtained in France in 1875, by which the French company were bound to spend £80,000. in preparatory works, the conduct of which was intrusted to a committee presided over by M. Lavalley, so well known in connection with the Suez Canal works. In addition to a new marine survey made by the company, a second boring was made at Sangatte, and the results of this work were published in 1876-77, in the form of reports with maps and sections. Since then the company have sunk two shafts a little to the west of Sangatte, and have driven some short headings in different directions through the lower beds of the lower chalk, and they are now driving two longer headings by machinery. This is being done for the purpose of defining the position of the gault and lower beds of chalk.

Since 1880 the Southeastern Railway Company have been carrying on experimental works between Folkstone and Dover. They have sunk two shafts, one near Abbot's Cliff and one near Shakespeare Cliff. A third shaft is being sunk to the east of Shakespeare Cliff. Headings have been driven, from the two first shafts, in directions more or less parallel with the cliff in the lower beds of gray chalk.

In a few words, the following is a summary of our geological knowledge of the question, as regards the chalk. Identical beds of chalk are exposed above the gault, in the cliffs on the two sides of the channel. These beds are on the two shores similar in composition, contain similar fossils and vary but little in thickness. Taken as a whole, they have a slight dip to the northeast. They have been found to pass uninterruptedly across the bed of the channel, on which the sections cut obliquely through them are exposed in bands stretching from shore to shore. Borings have shown that the lower beds increase rather than diminish in thickness as they dip below the sea level to the eastward of their outcrop.

Position and Line of Tunnel.—It will be necessary to assume certain requirements to be fulfilled by the tunnel before proceeding to discuss on what line it will be best to make it. I shall assume

1st. That it will communicate with existing railways in the ordinary way, by continuous railway ,and not as has been suggested by shafts and hydraulic lifts.

2d. It will be provided with a means of drainage by gravitation to the shore. That is, the water met with in the tunnel should be able to flow by gravitation from the summit level in mid channel to the shores of the two countries. This is necessary for safety during construction and for drainage afterward.

3d. The tunnel will be made for two li way, and be so designed as to be capable of being worked by ordinary locomotives.

4th. The gradient will be nowhere worse than about 1 in 80.

5th. Geology has told us the kind of strata which will be met beneath the channel. The experience of engineers gained in past works can alone determine through which of these strata, and through what part of them, it will be best to pass. Before attempting to do so due consideration should be given to the following questions:

1st. What are the military requirements with regard to the tunnel?

2d. Where must the tunnel end inland, in order to give the best accommodation to existing railways?

3d. What are the most favorable strata for the tunnel works?

4th. On what line will any error in our geographical calculations be of least moment?

5th. Which is the shortest practical sub-marine line?

The points where the tunnel can pass under the shore line in France are limited by geological conditions to the part of the coast which lies be-

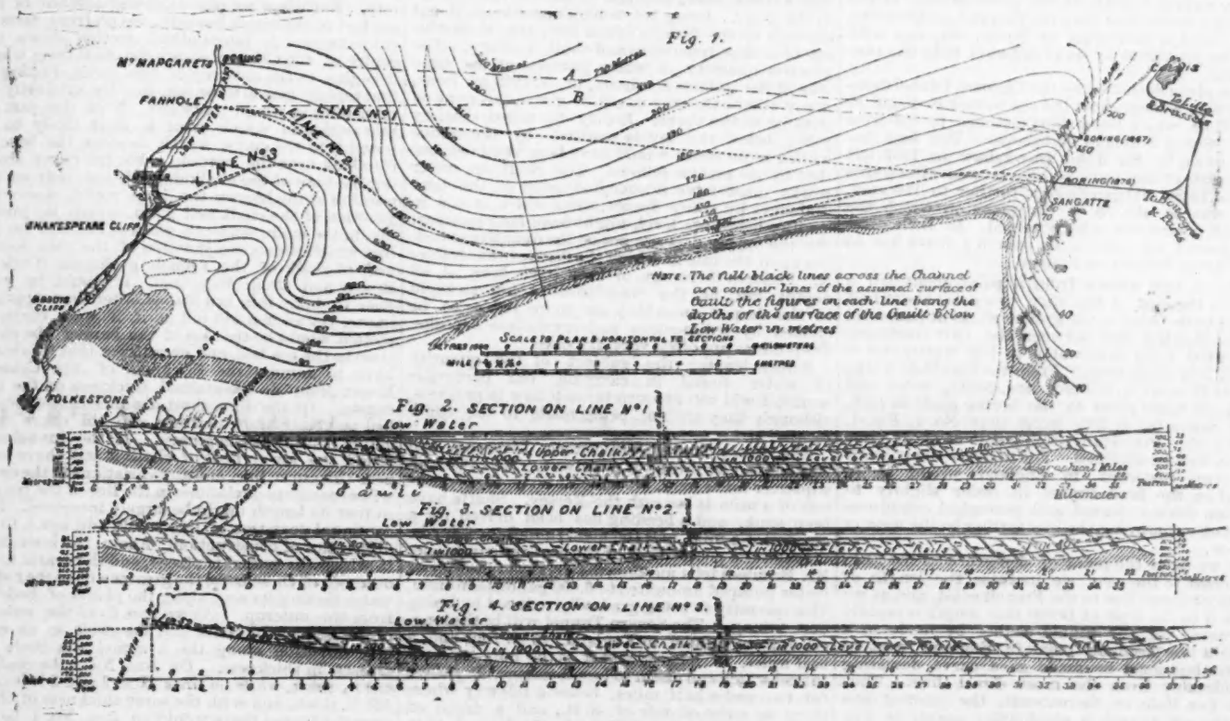
Fig. 1.
Nº MARGARETS BAY
FANHOLE
LINE Nº1
LINE Nº2
LINE Nº3
SHAKESPEARE CLIFF
ABBOTS CLIFF
FOLKESTONE
SANGATTE
BORING (1867)
BORING (1876)
Note. The full black lines across the Channel are contour lines of the assumed surface of Gault: the figures on each line being the depths of that surface of the Gault below Low Water in Metres
SCALE TO PLAN & HORIZONTAL TO SECTIONS
Fig. 2. SECTION ON LINE Nº1
Low Water
Upper Chalk
Lower Chalk
Gault
Fig. 3. SECTION ON LINE Nº2.
Low Water
Fig. 4. SECTION ON LINE Nº3.
Low Water

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tween the Ferme Mouron on the east (where the boring was made in 1867), and Sangatte on the west, a distance of about two miles. The country for some way inland throughout this distance is low and flat, and probably looking to military requirements, or to communications with existing railways alone, it is not very material within these limits where the tunnel first reaches the coast. The case is very different on the English coast. Geological conditions will admit of the tunnel passing under the shore line, any where between St. Margaret's Bay on the east and Shakespeare Cliff on the west, a distance of 4½ miles. With the exception of the valley of the River Dour, which enters the sea at Dover, the land along this part of the coast is high, bounded by chalk cliffs from 200 ft., to 500 ft. high.

Such being the nature of the coast there are only three places where the exit from the tunnel can be made: In the valley of the Dour near Dover, inland in the chalk escarpment to the mouth of Folkestone, and in the landslip between Abbots' Cliff and Folkestone; and physical and military considerations exclude the two latter. The exit at the first-named place can be placed at a moderate height above high water level, which means a shorter length of tunnel, and better gradients between the tunnel mouth and the lowest point of the line beneath the sea. It can be placed either within or without the fortifications, as the military authorities may require; and, as the existing railways terminate at Dover, they can with ease be connected by short railways with the tunnel line.

The plans deposited by the Channel Tunnel Company this session show the sea tunnel to begin at Fan Hole, which lies a short distance to the west of the South Foreland lighthouse. The first line laid down by Sir John Hawkshaw in 1867 left our coast at the same point. It was afterwards moved to St. Margaret's Bay, further to the east, and was so shown in the plans on which the French concession was obtained. In both cases the tunnel was shown to pass in a direct line to the Ferme Mouron in France.

Now, a line drawn from a point about half a mile to the east of Fan Hole to a point about half a mile to the west of the French works at Sangatte, is the shortest line between the two countries, measured from low water to low water, and is about 20¼ miles long. From the Fan Hole to the Ferme Mouron, in a direct line, is 21⅛ miles, and from the same place to the boring made in 1876, near Sangatte, is 20¾ miles (line No. 1, Fig. 1, page 232). Practically, this last is as short a line as can well be obtained. For to move the point of departure eastward in England would be to lengthen the land tunnel in order slightly to shorten the sea tunnel, and geological conditions prevent our moving the line further to the west in France.

As we move the point of departure on the English coast to the west we increase the length of the most direct line to the French coast, and as we move it to the west of Dover this length is rapidly increased; for the tunnel cannot be made in a straight line from any point in England west of Dover, but must be made in a curve deviating considerably from the most direct line. Thus from Fan Hole, or thereabouts, the shortest line for the sea tunnel is obtainable; again, as Fan Hole is distant a little over two miles from Dover, it is, at the minimum distance, required to pass with a gradient of 1 in 80 from the mouth of the tunnel to the required depth below the shore line, and thus we get the shortest possible land tunnel. I think that so far it has been shown that everything is in favor of the tunnel terminating in the valley of the Dour and passing beneath the shore line near Fan Hole. It remains to be seen how far these advantages are outweighed by any geological conditions afforded by the Folkestone route.

The only reason which has been given for taking the tunnel under the shore line to the west of Dover is, that by so doing it can be made wholly in the lowest beds of chalk. It is asserted that no water, or very little, will be found in these lower beds. Now what are the facts? We are told that little water is found in the heading from Shakespeare Cliff. That may be so, as far as it has gone. In the headings driven at Sangatte, in the corresponding beds in France, water is met with flowing from fissures at the sides and bottom, and not confined to one place, but throughout the headings. The quantity which I saw was not large—the largest spring, perhaps, 30 gallons per minute—but it is enough to prove that those beds are not impermeable; and no one can assert that where small water-bearing fissures exist larger ones may not be met with. It is fair to conclude, from all available evidence, that, on the French side, water might be met with largely 60 ft. above the green-sand, or allowing 36 ft. for the depth occupied by the tunnel and its masonry, 24 ft. only above the tunnel, supposing it to be driven continuously along the top of the green-sand. On the English side, as the water is found only 33 ft. above the green-and, the top of the tunnel would be in this water-bearing zone on the same assumption. It is needless to say that no railway tunnel could be driven along the top of the bed, following all its flexures. Thus, if the evidence from the permeability of the strata on land proves anything, it is that a tunnel driven in the lowest beds of chalk must come very near a bed from which large springs are discharged on land, and that it will probably have to pass into this bed. I may here remark that it is a fallacy to suppose that if a heading were driven across the channel in one bed, without meeting with water, it would prove that a tunnel could be driven on the same line equally free from water. The vertical depth of a heading is only 7 ft., that of the excavation for a tunnel would be at least four times that depth. In the Severn Tunnel works, headings have been driven in perfectly dry strata, yet, when the same have been enlarged for the full-sized tunnel, large quantities of water have been met with in the adjoining strata.

The work, which has tested to the fullest our power to tunnel through the wettest parts of the chalk is the Brighton intercepting sewer, for which Sir John Hawkshaw was engineer. The main sewer is more than seven miles long. The outfall is placed on the coast, about four miles to the east of Brighton; and, throughout a distance of about four and a half miles, a tunnel, from 9 ft. to 10 ft. in diameter, was excavated in the upper chalk, along the base of the cliff, and close to the shore. Being below high water level, it cut through all the fissures which discharge the drainage of a large tract of inland chalk country. The greatest quantity of water pumped at one time was 10,000 gallons a minute, or 600,000 an hour; many other examples might be given, but none so striking as the above. It may be urged that, by going below the levels reached by the above works, more water would have been obtained, but that by no means follows. The Brighton sewer works must have intercepted most of the land drainage; by going deeper, some water, stored in cavities below sea level, might have been pumped. But the supply depends not on the quantity stored, but upon the rate at which the fissures can deliver it. Fissures there are, or they have been, at all depths; but, as the circulation is not so rapid in the deeper ones, they are more liable to be choked by sedimentary and crystalline deposits. Deep mines are often very dry ones.

Before leaving the subject of the quantity of water found in carrying out particular works, I will refer to two tunnels now in progress, although they are not being made in the chalk formation.

The Mersey Tunnel will connect Liverpool and Birkenhead by means of a railway. It is two and a quarter miles long, of which nearly three-quarters of a mile is beneath the Mersey. Shafts have been sunk, and a heading has been driven for a quarter of a mile, and the main tunnel for 600 yds. through the pebble beds of the new red sandstone. Mr. Brunlees tells me that the greatest quantity of water pumped amounted to 6,000 gallons a minute. This quantity is being gradually reduced by lining and tubing. The Severn Tunnel will be the longest railway tunnel in England, in all four and a half miles, in length; and it is the only railway tunnel which can claim to be submarine. It passes, for two and a half miles, below a tideway where there is a rise of tide of 40 ft., and a depth of water at high water of 90 ft. in the deepest part of the channel. It passes, for a considerable portion of its length, through the Permian red marl, which has many points of resemblance to the chalk. The marl, which is in nearly horizontal beds, is much fissured, and from these fissures, as well as from spaces between the planes of bedding, much water is discharged. At the English end of the submarine part of the tunnel, for some distance, there is only from 35 ft. to 40 ft. of this open-jointed red marl above the brick work of the tunnel, which is already finished where the cover is thinnest. Salt water flows freely into the work; and, to show how the water channels are disconnected, salt and fresh water have, in some cases, flowed from adjoining fissures, and the fresh water has been allowed to flow, for drinking purposes, through pipes built into the brickwork. The largest quantity of water has been met with on the land portion of the tunnel; and the largest spring met with was in the land tunnel. It discharged 5,000 gallons a minute, and burst suddenly into a heading, which had been driven for over 1,000 ft., in millstone grit, without meeting with any water. If the heading had been driven at a level of 10 ft. lower, the spring would have been avoided in the heading, but would have been met with when it was enlarged to the full size of the tunnel. The total quantity of water now being pumped is between 7,000 and 8,000 gallons a minute. The examples I have given show that engineering works need not be stopped, even by large quantities of water; and, much as we know of the chalk and its water-bearing qualities, there is nothing to show that water would be met with in such large quantities as to stop tunneling, even in the upper chalk with flints.

A tunnel can be made from Fan Hole, in a direct line to the French coast, wholly in the upper part of the lower chalk, without flints, as will be seen from the section of line No. 1 of the plan; but, as has been already stated, a tunnel could be made from the same place, if it were advisable, for nearly three-quarters of the whole distance, in the lowest beds of gray chalk. To do this, it would be necessary to curve the line of tunnel southwards after leaving the shore, and then eastwards, as shown on the plan in line No. 2. This would make the sea tunnel nearly one and a half miles longer on line No. 2 than on line No. 1. That is, the certain immediate cost of making one and a half miles of tunnel, with the prospective disadvantage of one and a half miles more sea tunnel, to work, maintain and ventilate would be incurred, to save the cost of possible excess of pumping on the one route over the other.

It is important to consider on what line an error in our geological calculations will be of least moment to our tunneling operations. The map and sections to which I have referred are all based on the result of the French company's work. The marine and geological survey was made with care and precautions, such as were probably never before taken, and is an admirable piece of work. As long as it deals with the surface of the sea bottom, the reports and accompanying plans and sections probably tell us a true story, on which we may rely. But when we pass from the surface of the sea bed to the strata beneath, we go from facts to conjectures. A longitudinal section down the centre of the Channel shows the chalk from where it begins, at the out-crop of the gault, dipping at first rapidly beneath the sea, the dip gradually diminishing as we go eastward. Now the part of this section in which error is most likely to be found is in the curve which denotes the base of the chalk near the outcrop. For the curve showing the base of the chalk depends not only on the position of the line on the map which shows the junction of the chalk and gault, which is, probably, in the main, correctly plotted, but also on the line which shows the junction of the two lowest beds of chalk of the French geologists (Craie de Rouen and Craie Moyenne). It would be very rash to take this last line as other than approximate, yet all it could tell us if it were correctly plotted would be the dip of the base of the chalk close to the sea bed, and even to get that we should have to assume the thickness of the Craie de Rouen from its ascertained thickness on the two coasts. Of the dip a short distance below the sea bed we really know nothing, and the curve indicating it must be imaginary. If the tunnel is to follow the lower beds of chalk it will have to be near this curve line, and any variations in the curve will necessitate deviations in the line of the tunnel, so that its length might be largely increased. This continual deviation of line would add much to the difficulties of construction. Again, the lower beds in which the tunnel is placed, and the nearer to the outcrops of those beds, the greater will be the risk of water finding its way along the planes of bedding from the outcrop. As we pass from the outcrop of the base of the chalk and the gault in an easterly direction along the Channel the chalk increases in thickness. On line No. 1 the chalk is 480 ft. thick, while on lines Nos. 2 and 3 it is only 235 ft. thick, and with the same thickness of chalk over the tunnel there would on line No. 1 be 245 ft. more below the tunnel. I have given a third section across the Channel along the line numbered 3 on the plan, and the position of a tunnel is shown on it in continuation of that shown on the section deposited by the South-Eastern Railway Company. This tunnel does not keep wholly in the lower beds of chalk, so that it does not fulfill the requirements which a tunnel beginning to the westward of Dover should. That it may do so one of two things must be done: the line of the tunnel shown on the plan must be depressed some 150 feet, so that it may follow the lowest beds across the depression shown in the section, or we must bend the line No. 3 shown on the plan more to the west, so as to follow the lower beds of chalk, where they are found at a higher level nearer to their outcrop. The first course would render it impossible to make a drainage heading to the shore in the chalk, for the tunnel would be so low at its lowest point that it would not be practicable to obtain a fall in the chalk to the shore. This drainage heading has been already stated to be a necessity. The alternative remains, but it would make the submarine tunnel at least one mile longer than line No. 3, which is already three miles longer than line No. 1 from Sangatte. That is to say, to avoid passing for a few miles out of the lowest beds of chalk, the total length of the tunnel would be increased by nearly four miles, beside incurring the other disadvantage of the Folkstone route. Four miles of sea tunnel would not cost far short of a million, an amount which would pay for 4,000 horse-power at work, night and day, pumping for nearly seven years—a power which would raise more than 40,000,000 gallons each twenty-four hours. In deciding on the best line for the Channel tunnel, the quantity of water which may be

met with is but one of many factors to be taken into account. The Folkstone route would sacrifice all those of known value for the one of which the value is least certain. No tunnel will ever be driven under the Channel without meeting with some water, and an attempt to make one without ample preparations for dealing with a large quantity of water will only lead to waste of money and perhaps failure.

The following is a summary of the advantages to be obtained by making the tunnel in a direct line from Fan Hole to Sangatte: the shortest sea tunnel; as short a land tunnel as by any line; a greater thickness of chalk through which to tunnel; the best terminations for effecting junctions with the existing English railways; a termination affording facilities for defense at a less cost than elsewhere. No certain advantage can be claimed for the Folkestone route, and, as compared with the route to the east of Dover, it has the following disadvantages: The sea tunnel must be, at least, three miles longer; the land tunnel must be four miles longer, unless the mouth is placed in the Folkestone landslip; the chalk on the line of tunnel will be only half the thickness—in round numbers, 250 ft. against 500 ft.; it will emerge near no fortifications, nor can it be connected with the London, Chatham & Dover Railway Company's line at Dover; further, this tunnel must be made, for a great part of its length, near the outcrop of the chalk on the sea bed which should be avoided.

Ventilation.—It may be taken as an accepted fact that a Channel tunnel worked by an ordinary locomotive would require artificial ventilation. The matter was discussed at some length at a meeting of the Institution of Civil Engineers in 1876, when Mr. Morrison read a paper on the subject. Most extravagant estimates were then made of the number of horse-power required to ventilate the tunnel. The paper itself, and an account of the discussion which followed, will be found in the Minutes of the Proceedings of the Institution of Civil Engineers. If the attempt be made in a tunnel 20 miles long to create, artificially, a sufficient velocity in the air to maintain it in a state of even comparative purity, the difficulties will be found to be very great; but, if it be divided into sections, each five miles long, and these sections be treated separately, the difficulties, in a great measure, disappear. The distance between the ventilating shafts on line No. 1 would be about 21 miles; but to simplify the calculations, assume a tunnel 20 miles long, with descending gradients of 1 in 80 to points distant 5 miles from each shore, and rising from thence of 1 in 1,000 for the 5 miles to the center. The drainage headings, each with a falling gradient of 1 in 1,000 to the pumping shafts on the shore, will begin at the lowest points of the tunnel, midway between the centre and the shores where the two gradients meet. If the main tunnel be circular, with an internal diameter of 30 ft. and an area of 470 sq. ft. above rail level, air passages may be formed below the rails, having an aggregate area of 106 sq. ft. The drainage heading may also be circular, with an internal diameter of 17 ft., and a sectional area of 227 sq. ft. This will not be much in excess of what is required during the construction of the tunnel, for the greater part of the material excavated and materials for construction will be taken out and in through the drainage heading. If air is now drawn out of the drainage heading with a velocity of 10 miles an hour, it will produce a velocity in the tunnel of 2.4 miles an hour, supposing the air exhausted from the tunnel to be replaced at the shore ends from the shafts, and at the center from the air passages below the rails. If 48 trains pass through the tunnel in 24 hours, at intervals of half an hour, the air will remain pure at the shore ends and in the center. Between those points, the quantity of carbonic acid in excess of that normally contained in air, (3½ parts per 10,000 of air), will gradually increase, until it reaches a maximum at the points midway between the center of the tunnel and each shore, where it will amount to 12¾ parts per 10,000 in excess, or 16¼ parts altogether. The average condition throughout the tunnel will be 6.34 parts in excess, or 9.84 parts in all. Dr. Angus Smith, in his work on air and rain, states that in his own study he found 10.4 parts of carbonic acid per 10,000 parts of air. In theaters it has been found to vary from 20 to 32 parts; in the Chancery Court between 19 and 20 parts; and the air in a first-class carriage, between Gower street and Kink's Cross, with the windows open, contained 22.5 parts per 10,000 of air. Thus it will be seen that if such a state of things as is described above could be maintained in the tunnel, there could be no cause of complaint. To do this in a tunnel 20 miles long would require 460 effective horse-power, or 230 effective horse-power in each country. In a tunnel in a direct line between Fan Hole and Sangatte less than 500 effective horse-power would suffice. The cost of keeping this amount of horse-power at work would be a mere fraction of the working expenses of the tunnel, which, for many reasons, should not be as heavy as those of other nes.

COLONEL WARING AND PHILADELPHIA SEWERAGE.

In response to an invitation by the Finance Committee of Councils, Col. George E. Waring, of Newport, the expert and special agent of the Census Office, appeared before them last night that they might have the better opportunity to judge of the feasibility of the ordinance, now under consideration, which provides for his employment to inspect the sewerage system of the city and report plans for its improvement.

Upon being introduced by Chairman Clay, Col. Waring said that, except through private letters, he had had no knowledge of the ordinance until invited to attend the meeting of the committee. In response to inquiries by Messrs. Bardsley and Page, he soon, however, gave his opinion on the drainage of the city.

"I have been," said he, "since 1854, a drainage engineer, in constant practice of my profession, except during the war. I have examined all of the notable sewerage systems in Europe and America, and have tried to keep myself informed of the progress of my profession, and particularly in regard to whatever affected sanitary matters and the drainage of houses, cities and towns. I should not hesitate to accept the undertaking proposed in the ordinance, and I can say that, from what I already know, radical changes should be made in your present sewerage system."

"Is it probable," inquired Mr. Page, "that you would recommend the adoption of any patented system or appliances connected therewith?"

"If I come here," said Colonel Waring, "it will be as an engineer. In my experience in towns of minor size I found that the system of separate sewerage would best avail, and by certain additions to the apparatus and designs for such work I am now prepared to derive more than professional fees for my labors. There are parts of Germantown and other outlying districts where the separate system could no doubt be used with good results, but in the built-up portions of the city it would be impracticable."

WHY THE SEWERS BECOME CLOGGED.

"What are the most notable defects in our sewers?" inquired Mr. Bardsley.

"The examination upon which my report to the National Board of Health was based," said Colonel Waring, "was made by my Assistant Civil Engineer, William Henry Baldwin. Of course after a personal inspection I would be better able to answer. In the first place the condition of your branch sewers should be improved, and they should not be allowed to clog up. You are using in too many places a three-foot sewer where a twelve-inch pipe would do better service. Your fault is less one of design than of large sizes for small lengths. They should be of such a size that they would be thoroughly washed out by every heavy rainfall. Up to 18 in. diameter iron pipes are cheaper than brick sewers. Then again are the faults of bad construction and careless jointure. Sewers are mended and the débris which falls into them is left to dam up the flow and generate corruption and decay."

"Perhaps your greatest defect is the want of a proper responsibility in the department. One man designs the sewer, another builds it and the third cleans it out, or professes to clean it out. There is no one man who can control the system or to whom you can assign the blame for its defects. The refuse must soon be disposed of in another manner. The city cannot afford to have it discharging into the Delaware, where the flow of every tide carries it to the reservoir pumping station."

DEATH IN THE DRAIN PIPES.

"How about the ventilation of the sewers?" asked Mr. Hall.

"I would use neither street openings nor tubes," said Colonel Waring. "Each householder should be required to run the drain pipe which carries the sewage from his house up to the roof. It should be left untrapped, and then every discharge of sewage all through the city would be followed by a draft of fresh air. With such sewers as yours the impregnation of the soil by noxious gases is much to be feared. It would cost little more to make them fit to do the duty for which they are designed. They should be cemented inside and out, the joints tightly closed and the material of the best, and they should be kept clean. But defective house drainage exerts influences as baleful as do the most wretched sewers. The greater number of the cases of disease which doctors attribute to sewer gas is due to fault not in the sewers themselves, but to the filthy pipes which carry off the house drainage. Illuminating gas very often escapes from the pipes into the sewers, and most of the explosions are apparently due to that cause.

"The gas mains should not be permitted to run through the sewers. I see no objection, in so far as the purity of the water is concerned, in running the supply-pipes which carry a strongly-flowing stream through the sewers. Their gases cannot impregnate a strong current of water."

"But does not the comparatively low death-rate of Philadelphia show that her sewerage system is less defective than is commonly supposed?" ventured Mr. Bardsley.

HOW TO REDUCE THE DEATH-RATE.

"It shows nothing of the kind," quickly responded the engineer. "A low death-rate is no guarantee of good sanitary arrangements. You must remember the advantages of your healthful climate. You must bear in mind that here nearly every man rears his family in a home where air, light and sunshine are obtainable; that the tenement system is practically unknown. I judge your sewerage, not by your death-rate, but by my own ears, nose, eyes and knowledge. Perhaps if you enjoyed good drainage fourteen people might die where eighteen die now. It is the difference between your death-rate and your possible death-rate which must be considered.

"In New York, except in the older and lower portion of the city, the sewerage system is vastly better than here. The branches are small, tight, clean, washed out by every rain that falls. In Boston they are spending money by wholesale upon their main sewers, but their old branches are in worse condition than yours."

In response to an inquiry how he would conduct his examination in the event of the passage of the ordinance, Colonel Waring said that he would send Mr. Baldwin, his assistant, who made the former examination, to thoroughly inspect the sewers and to report to him the worse defects and best results of the system. He would then himself make a thorough inspection and would report the results, with his suggestions, to Councils.

On motion of Mr. Hall, the thanks of the committee were extended to Colonel Waring. The consideration of the ordinance was postponed pending the consideration of the appropriation bills.—*Philadelphia Times, Oct. 3.*

RECENT INVENTIONS PATENTED DURING THE PRESENT WEEK (OCT. 3).

MEANS FOR OPERATING DOORS OF ELEVATORS.

In this invention the doors are counterweighed to close them and opened by centrally pivoted levers on them, one end of which lever bears against the side of the shaft when a cam on the elevator rides against the lever, so opening the door. As the elevator leaves the door it leaves the lever in position to be operated by it on its return.

ENDLESS PACKAGE ELEVATOR.

This package elevator is composed and constructed of companion endless ropes, preferably of wire, connected together by and carrying a platform or a series of platforms, adapted to bear loads, and traveling around suitable pulleys provided at each terminus.

RAILWAY SWITCH.

An invention patented this week for a railroad switch comprises a shifting lever which is actuated through rotating spirally flanged treadles, one of said treadles being mounted in sliding bearings, whereby it can be moved out of the path of the wheel-flanges of the coming train when desired. The device is capable of operation by hand through a spring hand lever, which engages the connecting rod of the shifting lever.

FIRE-ESCAPE LADDER.

A folding fire-escape ladder is composed of wooden and iron side links, and tubular rounds and suitable metallic rungs or rods extending through the rounds and both sets of links, forming hinge joints.

UNDERGROUND CROSSING CABLE FOR STREET-CAR PROPULSION.

Where cables cross each other are placed inclined guide-ways, beginning below said cables and meeting at the point of crossing above said cables. The car is provided with a vertically sliding bar carrying on the bottom friction wheels adapted to travel on said guide-ways, and disengage the clutch from the cables.

SKELETON IRON STRUCTURE.

The sections of the pipe supports or columns are coupled together by couplings, through which pass bolts, which secure them to spiders or rings within the circle formed by said supports. The upper ends of the top sections are secured in a cap or head.

WATER OR GAS PIPE.

This new article of manufacture consists of an open-ended tube, comprising a sheet of metal rolled or overlapped to form the required diameter, and provided between the folds with solder suitably applied and adapted to set, thereby constituting a homogeneous solid cylinder.

WASHINGTON, D. C. F. B. BROCK.

ENGINEERING NEWS
AND
AMERICAN CONTRACT JOURNAL.

Tribune Building, New York City.

GEO. H. FROST.....EDITOR AND PROPRIETOR.
S. D. V. BURR.....ASSOCIATE EDITOR.

SATURDAY, OCTOBER 7, 1882.

EDITORIAL ANNOUNCEMENTS.

Terms of Subscription.—To the United States and Canada, $4 per annum, including postage; all parts of Europe, $5, payable in advance. Remittances at the risk of the subscriber, unless made by registered letter or by draft, check or P. O. order, payable to GEO. H. FROST.

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Articles for Publication in the current number should be received at the office of publication not later than Thursday morning, and advertisements not later than Friday noon.

Correspondence upon subjects which naturally belongs to the province of this journal is solicited.

CONTENTS.

	PAGE.		PAGE.
The Channel Tunnel (*Illustrated*)	347	Engineers and Engineering in Foreign Lands (*Illustrated*)	350
Colonel Waring and Philadelphia Sewerage	349	CORRESPONDENCE: Staking out Switches	351
Recent Inventions Patented During the Present Week	349	The Asheville Water Works	351
EDITORIAL DEPARTMENT: Notes	350	The Metric Chain	351
The Reform of the Sewers	350	American Society of Civil Engineers	351
		The Forth Bridge (*Illustrate*)	351
		General Intelligence	353

THOSE WHO DID AND THOSE WHO DID NOT.—Elsewhere this week we publish the bids received by the Department of Public Works this city, for building a reservoir. No advertisement was inserted in ENGINEERING NEWS and but five proposals were presented. Fremont, O., and Orange, N. J., advertised in ENGINEERING NEWS for bids for building water-works, and each received proposals from more than 30 firms. A well-known bridge contractor recently told us that he had just returned from two bridge lettings. One bridge was advertised in ENGINEERING NEWS and there were 17 bids; the other was not and there were but 2 bids—the gentleman who told us the incident and another. They divided up the work. The above are only a few of the many facts we could give. Those who have contracts to let and those who wish to obtain contracts will be benefitted if they ponder well the above.

THE REFORM OF THE SEWERS.

The members of the finance committee got a good deal of information gratis from Colonel Waring, but they ought not to stop here. A precise and detailed report from such an authority upon the existing faults of our drainage and their proper remedy would be of the utmost value and would be had very cheap at the sum it is proposed to appropriate. In a general way, of course, everybody knows what Colonel Waring told the committee about the faults and shortcomings of our sewers and of the shiftless system under which they are built and maintained, but this is a matter in which mere general knowledge will not avail. Indeed a chief source of trouble has been that one man's knowledge has been supposed to be as good as any other man's, and main sewers and branches have been built in a piecemeal fashion wherever or however a committee of the Councils or an individual Councilman, the Chief Engineer or a District Surveyor or a Highway Inspector thought best. We all acknowledge now that we have been going wrong, and no doubt every member of the Councils has his own separate idea of what measure of reform should be adopted first. Plainly, the only way out of the tangle is to call in some one who knows more than the rest of us, not only about general principles but about the practical details of drainage, and to have him tell us exactly what we ought to do.

Naturally the Chief Engineer of the city should be competent for his task, but it must be remembered that the subject of the scientific drainage of cities has become a very large one, which it is scarcely possible for any man to master in all its bearings unless he make it his special study and profession. It would not, therefore, be any reflection on Mr. Smedley, whose routine duties are enough to absorb his time, to call in a consulting engineer, even if so much of his own work, or work for which he is officially responsible, were of a part of the very thing that needs reform. In professional advice of any kind, the only safe rule is to get the best, and no one questions Colonel Waring's pre-eminence in the particular branch of his profession to which he has devoted a quarter of a century of study and observation at home and abroad, and in which he has attained important practical results. He is not the only authority on the subject, but he is doubtless the best, and, therefore, his recommendations would have a weight that would not attach to those of any resident engineer.

There is very little use of undertaking any extensive improvements in the sewers, however urgently required, without a clear understanding of what is to be done and how. We can all of us find fault, and all of us can make suggestions, each upon some small point that happens to have fallen under his own observation, but those amateurs who know the most will be the least forward with their own hobbies, and will best appreciate and value sound professional counsel. There is no subject pressing upon public attention here as important as this. Philadelphia ought to be not merely as healthy as other large cities, but very much more so, and we could spend money in no way to better advantage than in reforming our methods of drainage. But it is necessary first of all to know exactly what we have to aim at. There should be no more mere tinkering at the sewers.—*Philadelphia Times, Oct. 4.*

It was while the excitement of the "Trent Affair" was at its height that a prominent English journal gravely called the attention of the English government to the imminent danger of their Canadian possessions from the facility with which the Americans could march large bodies of soldiers during the winter over the frozen surface of Lake Ontario and thus capture Toronto, Belleville and Kingston. There are no people so loyal as colonists, and it was with a very visible tone of sadness that the Canadian journals commented on the deplorable ignorance of their "old country" contemporary. They were really ashamed of such an exhibit, where they felt only like deferring with unquestioning allegiance and respect.

It is with somewhat of the same feelings that intelligent people will read the above twaddle from so able and influential a newspaper as the Philadelphia *Times*, and this feeling cannot but be largely intermingled with surprise when they learn of the limited knowledge of sanitary matters that prevails in the second city of the Union, and the sluggish comprehension of a subject that is at the very foundation of their comfortable and healthy existence as inhabitants of a large, and in some portions overcrowded city. Now, any intelligent man—or woman either—who gives the subject a thought, would expect a city of nearly a million inhabitants to have a man at the head of its Public Works Department who knows what a sewer is, and what its proper shape and size ought to be to do its ordinary work properly and economically. But it appears by a memorial (see page 211 *ante*) to Councils that the beauty and efficiency of egg-shaped sewers was only "discovered" in Philadelphia a few months ago, and that too by a *lawyer* named Sanders, who very gravely submits a circular to the *Committee on Surveys* detailing the importance of his "find," and recommending an immediate invitation to Col. Geo. E. Waring, of Newport, R. I., to come on and tell them what *he* knew about egg-shaped sewers, and whether or not they would be good for Philadelphia.

So it is that Col. Waring has been giving a "good deal of information gratis" to the wise men of our sister city. "Gratis" information is a commodity that Col. Waring is not usually accredited with giving, especially to a city that can pay its politicians so well as Philadelphia does, and therefore it is that this statement will probably surprise some of Col. Waring's clients who know just what it costs to "invite" him to have a little talk with them about sewer systems.

"*Naturally the Chief Engineer of the city should be competent,*" etc. We should say so. "*No reflection on Mr. Smedley, whose routine duties are enough to absorb his time,*" etc. Political or engineering "duties?" "*Col. Waring's pre-eminence * * * * he is doubtless the best,*" etc. —— —— —— —— —— Where now are Worthen, Chesbrough, Adams, Joseph P. Davis, Towle, and Croes, of New York, Gray and Shedd, of Providence; and Whitman, Turner, Wise and Moore, of St. Louis, to say nothing of Philadelphia's own "resident engineer," whose "recommendation would not have the weight" of the "best" from Newport—Rudolph Hering, who at the present time may with propriety be called better than "the best" authority on sewerage matters, since he has had a practical experience equal to that of Col. Waring; he has spent as much time, and with equal if not superior advantages, among the great cities of Europe to examine their sewerage systems, and in point of value to engineers and to the general public, Col. Waring can point to no such invaluable records of his labor or research as Hering's "Report on the Sewerage of Philadelphia," and his Report to the National Board of Health on the Sewerage of European Cities. Col. Waring's record is principally in popular magazine articles; he is pledged to one system—the separate—he is the active man of a Sewer Construction Co., of Boston, and he has a patent sewer appliance to push for royalties. In his interview with the Philadelphia Finance Committee he told them *not a single new thing.* Mr. Hering has embodied it all in his report, and both Chief Engineer Smedley and his political associates know it as well as Col. Waring does.

Why does not New York City, or Chicago, or Cincinnati, or Providence call on "the best authority" to come and smell their respective street atmospheres and give him a show for a royalty? Why does not Newport, R. I., adopt the plans of "the best authority" instead of calling in Chesbrough to tell them how to build sewers. Col. Waring is a very active, intelligent engineer, and a writer of very charming magazine articles on sanitary subjects. But when a great metropolitan journal advertises him as the "very best authority" on sanitary subjects in the United States, we beg leave to take strong exceptions, and say that the Philadelphia journal is very much like its English contemporary on the subject of the great frozen lake—it does not know what it is talking about.

ENGINEERS AND ENGINEERING IN FOREIGN LANDS.

(Specially Translated and Prepared for the ENGINEERING NEWS.)

The work on the Corinth Canal is now in full progress, and though the enterprise does not possess the same commercial importance as the Suez and Panama undertakings, nor their engineering difficulties, still it is viewed with great interest by European engineers. Periander, the tyrant of Corinth, Demetrius and Nero had an idea of cutting the isthmus. The remains of the work carried out by the orders of the latter are still not only visible, but well preserved. Demetrius had intrusted the Egyptians with the engineering works, but the race at that time was not that of the men who built the pyramids,

"Whose race was run
Before Antiquity begun."

They asserted that the level of the Gulf of Cornith was so much higher than that of the Gulf of Egina that the isles in the latter would be submerged if the isthmus was cut. The wily priests of Cornith also opposed the project. The trace adopted by the modern engineers is that of the ancients, and the wells and excavations of Nero's men will be utilized.

The climate is very warm, but tempered by the sea breezes, and thus the hygienic conditions are favorable. Mr. Gerster had charge of the survey of the three proposed lines.

The line No. 1 which has been adopted (Nero's) is 6,342 metres long measured on bottom; it is almost perfectly straight. But the rocks are high on each side, and the winds may be dangerous to navigation. The geological formation is mostly calcareous and sandy.

As the line is only six kilometres, no intermediate stations will be required. The transversal section will be of the same dimensions as the Suez Canal, viz: 22 metres at bot-

tom, with a uniform depth of 8 metres below low water. The entrance will be protected by jetties. The maximum height of the cutting above the bottom will be 86 metres, 79 centimetres. Generally European engineers prefer a tunnel when the cutting exceeds 17 or 18 metres. The tunnel of Gabelbach, in Bavaria, is, however, 27.40 metres, and there is another of 32 metres. The Huehuetoca cutting in Mexico is, however, 50 to 60 metres deep for a length of 800 metres. As the vertical cuttings of Nero show few landslips, it is believed that the tapering of $\frac{1}{6}$ which has been adopted for the rock mass will be amply sufficient. There will be two bridges. The total cutting is estimated at 9,835,000 cubic metres, which will cost 2 francs per metre, or thereabouts. The work is to be completed in four years.

New works in India—one a canal of 93 miles to unite the rivers arund Calcutta, and a partial revival of railroad and public works in most European countries—would seem to indicate very lively times next spring, provided no great contretemps ensues.

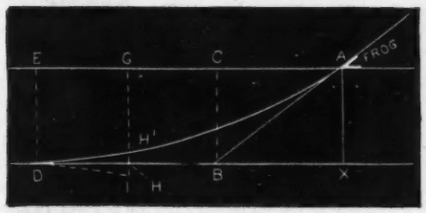
CORRESPONDENCE.

STAKING OUT SWITCHES.

ST. LOUIS, Oct. 1, 1882.

EDITOR ENGINEERING NEWS:

In reply to the question in the issue of Aug. 26, in regard to laying out switches, I would like to give the method which has been used in our office, and which we find thoroughly practical, hoping it may be of use to some of your readers.



To find radius of lead, and length of switch-rail for *a given frog*. (*Switch-rail considered part of turn-out curve*).

In triangle ABC, having angle A = frog angle; CB = gauge. Find AC and AB. (1)

AB will be tangent of required curve = T and angle $ABX = CAB$ = frog angle will be the intersection angle.

Then formula $R = T\ cot.\ \frac{1}{2}\ I$ (2) will give radius of lead (outside rail).

Dist. $AE = EC + CA = T + CA$ = dist. from heel of switch-rail to point of frog. (3)

To find length of movable switch-rail, to throw 5 inches (or any distance M).

In formula $d = \frac{C^2\ sin.\ D}{50}$ (Henck's Field Book sec. 19), value of d being given = 2 m (chord defl. = 2 (tang. defl.), transpose and we have

$$C^2 = \frac{d.50}{Sin.\ D}$$

in which C = length of switch-rail.

The actual field work consists of (after having located frog), measuring back a distance equal to EA to locate point where switch-rail should be left free, and then laying off the length of switch-rail to locate head-block.

If the turn-out is made from a curve but few modifications are necessary, W. P. B.

THE ASHEVILLE WATER-WORKS.

ASHEVILLE, N. C., Oct. 1, 1882.

EDITOR ENGINEERING NEWS:

In your issue of August 26 the following appeared:

"Asheville, N. C., is building water-works. C. L. Freeman, formerly connected with the Washington (D. C.) Water Department, is constructing Engineer."

In the Goldsboro *Messenger* of 29th ult. the following appears: "Work has been begun on the works for Asheville. The *Citizen* says there is an easily attainable supply for a population of 20,000 inhabitants." As I have received so many circulars and applications for a chance to furnish material, etc., I would state for the information of your many readers that I am only excavating on the side of a mountain of solid rock, for the reservoir, and I will advertise in ENGINEERING NEWS and *Sanitary Engineer* for proposals to furnish materials for the said work. In the meantime would like to receive catalogues and testimonials from the manufacturing fraternity.

C. L. FREEMAN, C. E.

THE METRIC CHAIN.

IN CAMP IN THE STATE OF SAN LUIS POTOSI, MEXICO, Sept. 16, 1882.

EDITOR ENGINEERING NEWS:

I trust that the gentle reader of ENGINEERING NEWS of August 26 was not beguiled into supposing that the singular experience of your correspondent, Mr. Kluegel, is representative of that of other American engineers in Mexico.

For a year past I too, like him, have used an alleged metric chain; but, unlike him, I am profoundly impressed by the importance of regarding the chain as a certain number of meters and not as an arbitrary unit in itself. My leveling rods are divided to centimeters, not to fractions of an arbitrary chain; and as I have to reckon gradients as a certain rise or fall per 100, it is plainly desirable that the length of the line be measured in meters. Width of road-bed, span of culverts, etc., are stated in meters, not in chains; and to compute the required cubic meters—not cubic chains—of earth-work and masonry there is a marked convenience in knowing the lengths along the line in meters. Again, we have frequently to state long distances from point to point in kilometers, which is readily done if lengths are recorded and stakes marked in dekameters and meters; but requires to be ciphered out, if the notes are made in chains independent of the meter. It is unnecessary to multiply illustrations such as will occur to any thoughtful engineer.

It seems to have entirely escaped Mr. Kluegel's mind that one great difference between system and confusion in metrology depends upon preventing each class in the community from setting up some unit of its own independently of other people. Why, for instance, do the arithmetics contain a mysterious apothecaries' weight table different from what is used in other kinds of business. The apothecaries of the United States, to their praise be it spoken, are now well on the way toward substituting the universal metric system for that old anomaly. Why do the arithmetics also contain a table of surveyor's measure, so-called, which is diverse from the length measure used by everybody except ancient surveyors and the U. S. public land offcials? Why did they used to contain separate wine-measure and beer-measure tables, as if vintners and brewers could not agree upon the same?

Now, that these and other relics of the past are gradually disappearing before the present spirit of unification it behooves engineers here to use the same chain adopted by the world generally. It is 20 metres long, and it should be kept in mind that it is thus 20 times the primary unit of length; twice the secondary unit of the length, the dekameter, by which railroad line stakes should be marked, and $\frac{1}{1000}$ of the kilometer, another secondary unit. F. B.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

The regular meeting of the Society was held Wednesday evening, October 4th. Vice-President William H. Paine in the chair; John Bogart, Secretary.

The recent death of President Ashbel Welch was announced by the Vice-President, and appropriate resolutions were passed on the subject, providing also for the publication of a memoir in the proceedings of the Society.

Senor Francisco de Garay, chief-engineer of the drainage of the Valley of Mexico, then gave an interesting address, describing the topographical features of the City of Mexico and the valley in which it is situated, and giving a history of the various attempts, more or less successful, that have been made for centuries to drain this valley.

He also described the methods now proposed to be adopted to effect that purpose.

THE FORTH BRIDGE.*

BY B. BAKER.

At the request of Dr. Siemens, the following short paper on the proposed Forth Bridge has been prepared, though the author himself would have preferred to postpone any communication on the subject to the British Association until the works were well in hand, and the many points of interest and difficulties inseparable from so gigantic an undertaking had manifested themselves. At the present moment a commencement has not been made, the whole period from the revival of the project last year until now having been occupied in the necessary preliminary work of obtaining the Act of Parliament and preparing the designs and specifications. It is believed, however, that in a few weeks the contract will be let, and an energetic start will at once be made with the works.

Before referring in detail to the history of the undertaking and to the character of the design, the author would like to convey, if possible, some notion of the magnitude of the proposed bridge across the Firth of Forth. In preparing the detailed designs he has often experienced no little difficulty in realizing the scale upon which he was working. For example, the bed-plates for an ordinary railway girder bridge, say a couple of hundred feet span, would be about half the size of an ordinary dining-table, and it is difficult at first to picture to oneself a bed-plate about double the size of an ordinary dining-room, but that is the size of the bed-plate for the Forth Bridge girders. A diagram hanging on the wall shows the comparative sizes of some of the largest girders and arched bridges in the world, but even this fails, in the author's opinion, to impress upon the mind the vast difference in scale between the proposed and all previous bridges. On glancing through the last volume of "Reports of the British Association," with a view to obtain a notion as to the ordinary length of papers for section G, he incidentally obtained a notion also for illustrating in popular but perfectly accurate terms the size of the Forth bridge as compared with the largest bridges in the country. In the report of the Anthropometric Committee it was stated the average stature of a new-born infant is 19.34 inches, whilst the average height of the Guardsmen sent out to Egypt has been officially given at 5 ft. 10½ in. These figures have a ratio of 1 to 3.65, and, singularly enough, as the largest railway bridge in this country, the Britannia Bridge has a span of 465 feet, and the Forth Bridge a span of 1,700 feet, the ratio there also is 1 to 3.65. Hence, to enable any one to appreciate the size of the Forth Bridge, we have merely to suggest the following simple rule-of-three sum: As a Grenadier Guardsman is to a new-born infant so is the Forth Bridge to the largest railway bridge yet built in this country. Bridges a few feet larger in span than the Britannia have been built elsewhere, but they are baby bridges after all.

Such being the size of the structure, the question naturally occurs, why it should be necessary or expedient to build so unprecedented a work far north in this little island of Great Britain, when it has been found practicable to cover the globe with railways and to carry roads across the greatest continental rivers without involving any such difficult undertaking. The answer is a somewhat complex one. It is not the physical features of the country, but the habits of the population that render the construction of a 1,700 ft. span expedient. If the British public can save a few minutes by going a particular route, by that route will they go, although the alternative one might be as eligible, or even more so, in every other respect. This fact was forced upon the attention of the North British Railway Company nearly twenty years ago, when they sought powers to construct a bridge across the Forth, to secure for themselves and their allies, the Great Northern, Northeastern and Midland Railways, a fair share of the through traffic between England and the North of Scotland, which they alleged had been hitherto practically monopolized by the London and Northwestern and the Caledonian railways, whose route was a few miles shorter. Parliament, satisfied, no doubt, that the contention was a reasonable one, granted the solicited powers in the year 1865. The bridge then proposed crossed the Forth at a different spot to the present bridge, as the engineer had not the courage to face a span of 1,700 ft., and nothing less is practicable at Queensferry. Owing to the treacherous character of the foundations, however, it became necessary to adopt another site, and, by bringing the point of crossing five miles further down stream to Queensferry, a considerable saving in distance was effected in the route between Edinburgh and Perth.

The Act for constructing a bridge at Queensferry was obtained in 1873. At this point the Firth of Forth is divided by the island of Inchgarvie into two unequal channels, but the depth of water in each is such that a smaller span than 1,700 ft.

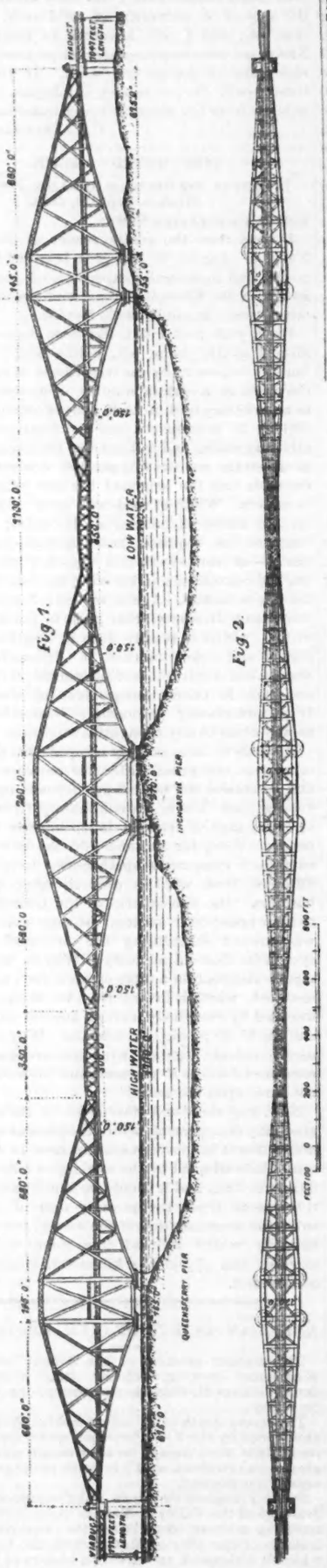
*Paper read before the British Association.

could not be economically adopted for either channel. North of Inchgarvie the maximum depth of water is 218 ft., and south of the same 197 ft. In the former channel the bottom is of hard trap rock, and in the latter partly of rock and partly of extremely stiff boulder clay. It is not the treacherous character of the bed of the Forth, therefore, but the depth of water which precludes the construction of intermediate piers. Pneumatic apparatus is inapplicable to such depths as 200 ft., and no responsible engineer would care to found the piers of an important structure upon a bottom which he had no means of examining by diving apparatus or otherwise.

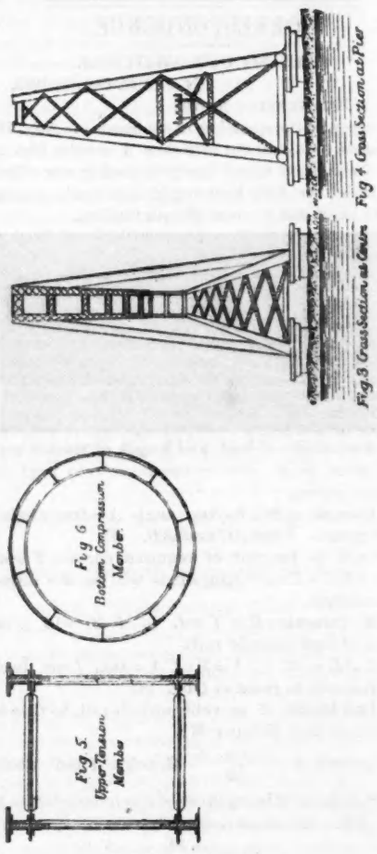
To the late Sir Thomas Bouch is due the credit of the bold proposition to cross the Forth in two spans of 1,600 ft., and to so avoid the necessity of intermediate piers in unprecedented depths of water, with all the consequent uncertainties and contingencies. A contract for the construction of Sir Thomas Bouch's great suspension bridge was made with Messrs. Arrol, and the preliminary works were in progress when the Tay Bridge fell. In consequence of the latter catastrophe, the directors of the Forth Bridge Company decided not to proceed with the works, and an Abandonment Bill was consequently promoted in the session of 1881. The North British, Great Northern, North-eastern, and Midland Railway companies, being interested in securing direct communication to the North of Scotland, objected to the abandonment of the enterprise, and instructed their respective consulting engineers, Mr. Fowler, Mr. Harrison, and Mr. Barlow, to report anew on the practicability and cost of crossing the Forth, either by a bridge or otherwise, at Queensferry or elsewhere. A careful reinvestigation of the whole question was accordingly made, with the result that the directors were advised that it was perfectly practicable to build a bridge across the Forth which would comply with all the requirements of the Board of Trade and public safety, and that the best place of crossing was at Queensferry. The Abandonment Bill, which had passed the Commons, was then withdrawn, and the engineers were instructed to agree upon a design. Modifications of the original suspension bridge were first considered, and Mr. Fowler and the author then submitted a project for a bridge on the continuous girdle principle. Mr. Harrison and Mr. Barlow, fully appreciating the advantages which would pertain to such a bridge, as compared with a more or less flexible suspension bridge, made independent investigations, and suggested several modifications. Finally, the design now before you (see cut) was unanimously agreed upon by all as the one to be recommended to the directors for adoption. The directors acted upon this recommendation, and, accordingly, the necessary plans were deposited, and an Act was obtained this year for constructing a continuous girder bridge across the Forth at Queensferry, having two spans of 1,700 ft., two of 675 ft., 14 of 168 ft., and six of 50 ft., and giving a clear headway for navigation purposes of 150 ft. above high-water spring tides. For this work Mr. Fowler and the author are acting as engineers.

It would probably be conceded by every one that a girder bridge would prove stiffer than a suspension bridge; but it is not so obvious that it would also be cheaper. Careful comparative estimates have, however, proved this to be so in the case of the Forth Bridge, and the reason is not far to seek. In a long span bridge the weight of the structure itself constitutes the chief portion of the load, whilst the pressure of the wind is at least as important an element as the rolling load itself, to carry which is the sole useful mission of the bridge. In a properly designed continuous girder for a long span bridge the mass of metal will be concentrated near the piers, where it will act with the smallest leverage and produce the least bending moment. In an ordinary suspension bridge, with stiffening girder vertically to provide for the rolling load, and horizontally to meet wind stresses, the mass of metal will be somewhat greater towards the centre of the bridge than at the piers, and consequently for a given mass the moment will be much less in the continuous girder than in the suspension bridge. Thus the Forth Bridge superstructure weighs but 2 tons per foot run at the centre of the 1,700 ft. span, and 13½ tons per foot run at the piers; whilst in a suspension bridge, as already stated, the weight of superstructure per lineal foot would be somwhat greater at the centre than at the piers. This consideration, coupled with the facts that suspension links are more costly than girder work, that a suspension bridge requires a very costly anchorage, and that the contingencies and risks during erection in a stormy estuary are very great, explains why, in such a case as the Forth Bridge, well-designed continuous girders form a cheaper, as well as a far stiffer, structure than a suspension bridge with stiffening girder.

Continuous girders, as a rule, are made of uniform depth, and it has been considered by some engineers a rather strained application of the term to so describe the Forth Bridge girders. But clearly it is the nature of the internal stresses, and



and not the external appearance of the girder, which should decide the question; and from this point of view the proposed Forth Bridge is in the strictest sense of the words a continuous girder bridge. By all authorities a beam is considered to be continuous if it is either rigidly or partially fixed as well as supported at each end in such a manner that a pair of equal and opposite couples act on the vertical planes at its points of support. In the case of the Forth Bridge, such continuity is attained by connecting together the ends of the two 1,700 ft. spans at Inchgarvie, and by projecting the other ends a distance of 675 ft. beyond the main piers, and weighting them to the required extent. The moment of the couples and the position of the points of contrary flexure in a continuous girder may be regulated at will, either by putting an initial stress on the girder, or by severing either the top or bottom member at the desired point. In the case under consideration the latter method has been adopted, and the question of the most advantageous position for the points of contrary flexure was a subject of elaborate investigation, as it was known to have a vital influence on the economy of the design. Having reference to all the conditions of the problem, it proved to be most advantageous to fix the points at a distance of 675 ft. from the piers, so that in effect the 1,700 ft. girder may be considered as made up of two cantilevers each 675 ft. in length, and a central girder 350 ft. in span.



THE FORTH BRIDGE.

Similarly, on investigation, the most generally advantageous depth proved to be about 50 ft. at the centre, and 350 ft. at the piers; and, this being settled, the next thing to be determined was the most advantageous width for the superstructure. Since the fall of the Tay Bridge, engineers generally, and the Board of Trade in particular, have vividly realized the fact that the severest wrench to which a railway viaduct is subject arises not from the vertical stress due to the loading of both lines of rails with locomotive throughout, but to the diagonal stress due to the combined action of the ordinary rolling load and a violent hurricane. In the case of the Forth Bridge this stress would act at an angle of about 45 degrees, so that, were it not for the dead weight of the structure, the required strength would be the same horizontally as vertically, and the economical width would be the same as the economical depth. Although the dead weight modifies this conclusion, it was obvious that the bridge should be a continuous girder of varying depth on plan as well as on elevation, and investigation showed the economical width of superstructure to be about 32 ft. at the centre, and 132 ft. at the piers.

It was open to consideration whether the wind stresses should be resisted by bracing together both the top and bottom members of the girder, or the bottom members alone. The author, however, never had any doubt that, as the stresses must sooner or later be brought down to the masonry piers, they had better be brought down at once by the shortest route along the bottom members only. The top members are therefore spaced at the distance of from 33 ft. to 27 ft. apart, centre to centre, and are unconnected by wind bracing. Each of the main vertical and diagonal struts consists of a pair of tubes spread out at the base like a bridge pier, and the wind stresses on the bracing between the tubes are much reduced thereby. In like manner are the wind stresses on the bracing of the bottom member reduced by the spreading out of the legs of the cantilevers, and the general stresses on the web members by the tapering depth from the piers towards the ends of the cantilevers.

Having thus blocked out the general outline of the girder, so that the shearing stresses from the diagonal action of the wind and load should be largely taken up direct by the main members, the next point was to determine the number of bays, and the angle of the web bracing. It was not infrequently assumed that 45 deg. was the most economical angle, but this was true only when the admissable stress was the same in compression as in tension, which was not the case either with wrought iron or steel, or where, as in the instance of wind bracing, the diagonals were subject to alternate compressive and tensile stresses. American bridge builders, as a rule, disposed their long slender struts vertically, and their diagonal ties at an angle of 45 deg., and as the question of competition entered into the problem, it might safely be assumed that economical considerations dictated this arrangement. The general slope of the web members of the Forth bridge was something between the angle of 45 deg. and the vertical, and, although the author was not prepared to contend that the disposition adopted was the most economical attainable, yet he was satisfied that it reasonably approached that limit.

Whatever the angle of the bracing, it was quite clear that, in a girder of 1,700 ft. span, exceptionally long struts would have to be provided, and it was a matter of much importance, therefore, that the struts and compression members generally should be of the most economical and efficient form. The advantages offered by a circular form of cross section were self-evident. A flexible sheet of drawing-paper, simply rolled upon itself, becomes transformed into a stiff column, as every one accustomed to handle plans and drawings well knew. Similarly, a thin sheet of iron or steel, bent into a tubular form, without further stiffening, offered as high a resistance per square inch to compression as the most heavily braced rectangular strut. The author recently tested a piece of ordinary stove-pipe, 4 in. in diameter and 2 ft. long, made of sheet iron only about a fortieth of an inch in thickness, and found it stood, without buckling, a compressive stress 15.9 tons per square inch, whereas one of the Britannia Bridge rectanguler cells, 18 in. square and 8 ft. long, made of plates and angles half an inch thick, crippled under a stress of 13.6 tons, or say 15 per cent. less stress than that sustained by the piece of stove-pipe. If flat plates, as much as half an inch in thickness, behaved so badly in a rectangular cell only 18 in. square, it is hardly necessary to speculate as to what would be the case in tubes 12 ft. square, which would be the size required for the Forth girders. With rectangular struts formed of four corner pieces and lattice sides, the required strength of the latticework has been found by experiment to be considerably greater than theory would indicate, and the form, therefore, is a very disadvantageous one as compared with a circular cross section where every particle of metal performs useful work. In a long span bridge it is essential to reduce the secondary bracing to a minimum, because the weight of metal itself constitutes the chief load. For that and for many other reasons, including the comparatively small resistance offered by a curved surface to the wind, the author, after carrying out not a few experiments himself, and passing in review the numerous experiments made by others during the past thirty years, was satisfied that a circular form of cross section was the proper one in the case of the Forth Bridge. All the main compressive members, therefore, will be tubes varying in diameter from 5 ft. to 12 ft., and only the wind bracing, subject to alternate compressive and tensile stresses, will consist of rectangular latticed members.

Between the two main girders, as described above, the double line of railway will be carried on an internal viaduct, supported by trestles and cross girders. The permanent way will consist of heavy bridge rails on longitudinal sleepers bedded in four steel troughs, the outer pair of which serve also as the top members of the girders of the internal viaduct, and the inner pair being simply rail-bearers. The width of the trough is such that, in the event of derailment, the wheels will drop into the troughs, and run along the timber sleepers clear of obstruction. A buckle-plate floor and parapet or wind screen will be provided of ample strength to insure the safety of the trains. No guard rails will be introduced, as the engineers and the Board of Trade are in accord in considering them a source of danger during high winds.

It is hardly necessary to state that the whole of the superstructure will be of steel. For the tension members the steel is to have an ultimate tensile strength of not less than thirty tons nor more than thirty-three tons per square inch, with an elongation of 20 per cent. in a length of 8 in. For the compression members the strength is to be from thirty-four to thirty-seven tons, and the elongation 17 per cent. In making the tubes and other members, all plates and bars which can be bent cold are to be so treated, and, where heating is essential, no work is to be done upon the material after it has fallen to a blue heat. The steady pressure of hydraulic presses is to be substituted for hammering wherever practicable, and annealing will be required if the steel has been distressed in any way. No punching or shearing will be allowed, and all plates will be planed at the edges and butts, and all holes drilled through the whole thickness of plates and angles after being put together.

Previous to the preparation of the designs and estimates, many consultations were held with the Board of Trade officers with reference to the maximum wind pressure to be provided against, and the admissible stress upon the metal. Existing rules limit the stress to 6½ tons per square inch, and it was desired to get this limit extended to 7½ tons. This was assented to by the Board, as the 6½ tons working stress was based upon the assumption of the steel having a minimum ultimate tensile strength of 26 tons per square inch, whereas the Forth Bridge steel was to have a strength of at least 30 tons. As regards wind pressure, the present Board of Trade provision of 56 lbs. per square foot has been adhered to, and that pressure has been assumed to take effect upon a surface equivalent to double the plane surface of the bridge, a deduction of 50 per cent. being made in the instance of the cylindrical surfaces. Under the combined action of the wind pressure, estimated as above, and a rolling load of two tons per foot run, or 3,400 tons on each span, the maximum stress would in no case exceed 7½ tons per square inch, whilst upon the members of the wind bracing subject to alternate compressive and tensile stresses, it would not be greater than 5 tons per square inch. In ordinary working—that is to say with heavy coal trains and light winds—the maximum stresses would be about 6 tons in tension and 5 tons in compression, which were about the same as the Saltash Bridge of 460 ft. span would be subject to under the same circumstances, and that bridge is of iron. Even assuming that such a hurricane as 56 lbs. per square foot could ever take effect over so large a surface as that offered by the 1,700 ft. girders, it was quite clear that no train could be on the bridge at the time, for a pressure of 30 lbs. to 40 lbs. would certainly stop the progress of any train. Without the rolling load the maximum stresses during the hurricane would, however, be only about 4¾ tons in tension and 6 tons in compression. Indeed, if the Forth Bridge were made of iron instead of steel, it would be a relatively stronger structure than either the Britannia or Saltash bridges, so that the 50 per cent. extra strength due to the adoption of the steel may be regarded as an addition to the factor of safety, and not as a necessity of the unprecedented length of span.

Continental and American engineers at the present time almost universally take note of the vast difference in the destructive effect of a live load and a dead load; but the Board of Trade entirely ignore this fact, and adopt the same limiting stress in a main girder, where the greater portion of the load may be dead, as in a cross girder where it is practically all alive, and where vibration is set up by every passing wheel. It is generally admitted—and the practice and experience of mechanical engineers confirm the conclusion—that metal of any class may be subject to a working stress twice as great under a dead as under a purely live load. Some engineers make a compromise and take the ratio at one and a half times. If this be done, and a factor of safety of three be adopted in the instance of a purely dead load, the admissible working stresses for iron having an ultimate strength of 20 tons per square inch would be 6⅔ tons for a dead load, 5⅓ tons for half dead and half live, 5 tons for quarter dead and three-quarters live (which is about the proportion obtaining in railway girders of 100 ft. span), 4⅓ tons for all live load, and 2⅔ tons for members subject to alternate tension and compression of equal intensity. With steel having a strength of 30 tons, the corresponding stresses would be 50 per cent. greater—that is to say, they would range from 6⅔ tons for an all live load to 10 tons for an all dead load. If the stresses be limited as above, the results of experiment and of actual practice show that a structure may be subject to an indefinite number of repetitions of the stress without injury. But, in the case of hurricanes, the repetitions will necessarily be few and far between, and higher stresses are therefore admissible in the members of wind bracing than in the piston rod of a steam engine, though both are subject to alternate tensile and compressive stresses. When it is remembered that the dead weight between the piers of the 1,700 ft. span is upwards of 10,000 tons, whilst the live load due to a couple of heavy coal trains would be less than one-tenth of that amount, the relative lowness of the 7½ tons per square inch maximum stress in the Forth Bridge girders, under the combined action of an impossible load and an improbable hurricane, will be conceded by all.

So far as the author is aware—although it has been established beyond all dispute that repeated application of a tensile stress amounting to two-thirds of the ultimate strength of the material would in time cause fracture—it has never been proved that the same conclusion applies to metal in compression. In fact, some of the authors experiments lead him to think that a contrary result might obtain. For example, one of the consequences of heavy varying stresses and vibration is that the quality of the metal deteriorates, both iron and steel becoming more crystalline and less ductile. These conditions are rather favorable than otherwise to the resistance of a compression member. Thus the author tested some columns, 30 diameters in length, of high class ductile steel, and of inferior crystalline steel, both having, however, the same tensile strength. The inferior steel bore 40 per cent. more load than the high-class steel, and it appears not improbable that, if the quality of the latter had been deteriorated by vibration and heavy stresses, the ultimate resistance would have been increased as regards compressive stresses almost as much as it would be diminished in respect of tensile stresses. Similarly, in columns of the same proportion, the commonest class of pig iron would beat the finest brands of wrought iron.

Long struts were avoided at any expense by some engineers, but, the author thought, without good reason. The tubular struts in the Forth Bridge, if made of iron, would resist as high a compressive stress per square inch as the top flange of any existing girder, and the same remark would apply to steel. An interesting series of experiments was recently made in America with full-sized wrought-iron hollow columns, from 8 in. to 12 in. in diameter, and up to 28 ft. in length. The influence of the length of the column on its resistance was singularly small. For instance, the 8-in. column when 15 diameters in length failed w th a stress of 16.2 tons per square inch; and as much as 42 diameters in length, with 15.6 tons. Now the model of the Britannia Bridge, 75 ft. in span, failed with 14.8 tons per square inch compression; Brunel's 66-ft. girder, having a 3 ft. wide cellular top member, failed with 12.6 tons; and some girders tested by the author with 15 tons per square inch as an average on the top flange.

Taking the mean results of a large number of experiments, the influence of length between the practical limits of 15 to 25 diameters would just be appreciable; but, if only a few experiments were compared, the deduction might be drawn that lengthening a column, or rounding its ends, increased rather than reduced its strength. Thus one steel tube 20 diameters in length, tested by the author, bore 22 tons per square inch, whilst a similar tube of half the length bore only 19.2 tons. Again, a round-ended column, 20 diameters in length, bore 19.3 tons per square inch, whilst a flat-ended one failed with 18 tons. No doubt greater regularity would obtain with full-sized than with model tubes, but still the practical fact remained that, within the limits occurring in the Forth Bridge, the compressive resistance of the tubular struts would be as high as that of the top flange of any plate or box girder that could be built, and that whatever stress was admissible in the girder would be admissible in the struts. This was a reassuring result to arrive at, because the practical experience had been chiefly with girders, and not with tubular struts.

(TO BE CONTINUED.)

GENERAL INTELLIGENCE.

☞ *We solicit and are always pleased to publish in these columns any items of interest that may be furnished us.*

GAS AND WATER.

THE QUESTION of water-works is being considered by Negaunee, Mich.

WATER FOR LOCOMOTIVES.—Long tanks, from which water can be taken by express trains without stop, are to be built by the Consolidated road between Bridgeport, Conn., and Fairfield, and at Rowayton.

ADDITIONAL WATER SUPPLY.—Northampton, Mass.,

has not yet settled its water problem. Engineer Davis estimates that it will cost $6,000, exclusive of land damage, to build another reservoir on Roberts' meadow brook, to increase the water supply, which would have a capacity of 12,000,000 gallons.

MINNEAPOLIS, Minn., is getting exercised over the questions of water supply and fire protection.

WASTE OF WATER.—At a meeting of the Boston Common Council held Sept. 28 the orders for an expenditure of $25,000 for the purchase and attachment of Deacon waste-water detectors, and for the appointment of not more than 20 inspectors of fittings, at a salary of not over $75 each per month, for a term not exceeding one year, came up by special assignment. A substitute was offered authorizing the Water Board to expend a sum not exceeding $70,000 for water-recording meters and putting the same in operation, providing that no meter shall be put on any house of a less value than $5,000; also authorizing the City Engineer to appoint 23 inspectors at a salary not exceeding $75 per month each. After some discussion the substitute was accepted and referred to the Committee on Finance, with instructions to report at the next meeting.

THE PINTSCH LIGHT.—The Providence Railroad is said to be so well satisfied with the Pintsch light on its steamboat train that there is talk of introducing it on all its trains. The invention, as at present perfected, consists of a tubular receiver placed under each car, with a capacity of 344 feet of gas, under compression of eight and one-half atmospheres, or 127 pounds to the square inch. From this tubes one-quarter of an inch in diameter run to the various burners.

NEWPORT'S WATER BOARD.—NEWPORT, R. I., Oct. 4.—George H. Norman was elected President, Mayor Franklin, Secretary, and C. B. Weaver, Treasurer and Superintendent of the Newport Board of Water-works this afternoon. The directors elected were William P. Sheffield, Lieut.-Gov. Fay, Mayor Franklin, T. M. Seabury, W. H. Sherman and Postmaster Coggineshall.

Messrs. J. A. Cloud & Co., of 18 Wall St., N. Y, have been awarded the contract for water-works for Lyons, Ohio Stand-pipe. Two million gallons daily capacity. Water to be taken from the Mahoning River.

THE WATER COMMISSIONERS of Rahway, N. J., have entered a protest against the city of Orange damming the Rahway River to supply Orange with water and diverting it from Rahway.

BENEFIT FROM ARTESIAN WELLS.—From being the dryest and one of the unhealthiest towns in Southwest Georgia, Albany has become perhaps the best watered town in the state, and while the country round about is as full of sickness as ever, it has had very little, indeed, of the customary sickliness. All this has been brought about simply by boring two artesian wells Over 500 ft. of boring was done at an expense of less than $1,500, and a supply of absolutely pure and ice-cold water fully sufficient to more than supply the wants of the city of 3,500 people is the result. Albany's example is being followed by several towns, and with the facts before them there is no reason why scores of South Georgia towns which are now regarded as unhealthy on account of their water should not become as healthy as the average.—*Atlanta (Ga.) Constitution.*

WORK has been begun on the water-works for Asheville. The *Citizen* says there is an easily attainable supply for a population of 30,000.

ELECTRICITY.

NEW TELEGRAPH COMPANIES.—The following companies have filed articles at Albany, N. Y.: The Commercial Telegram Company; capital, $50,000. (The lines of the company are to run from New York to different cities in this and other states.) The Mexican Northern Telegraph and Telephone Company, of New York: capital, $200,000. Its line is to run from New York through the State of New Jersey, and thence in a southwesterly direction to the city of Laredo and other cities in Mexico.

SAVANNAH, Ga., is partially lighted by electricity.

RAILROADS.

NEW ILLINOIS RAILROAD.—The Kaskaskia River, St. Elmo & Southern Railway Company filed articles of incorporation with Secretary of State on the 27th ult. The object is to construct a line of road from a point in Shelby County through the counties of Effingham, Fayette, Marion, Jefferson, Franklin, Williamson, Jackson, and Union to a point on the line of the Cairo and St. Louis railroad. Capital stock, $500,000. The incorporators are all residents of Effingham County.

THE OUBATONIC VALLEY Railroad Company is the name of a corporation organized to build a road from Shelton, Ct., to the New England road at Sandy Hook. The route has been surveyed, and work will probably commence in a short time.

CANADIAN PROJECT.—OTTAWA, Ont. Oct., 2.—A proposition has been made to A. Keefer, Secretary of the Ottawa, Morrisburg, Waddington and New York Railway and Bridge Company, on behalf of a syndicate composed of New York and English capitalists, having in view the acquiring of the charter of the company and the immediate construction of railways and bridges over the Ottawa and St. Lawrence Rivers. Mr. Keefer has been asked upon what terms the transfer will be made. Plans of the bridges and a profile of the whole line have been prepared and forwarded to New York and England, with a memorandum from Mr Keefer of the terms and conditions he requires. A meeting of the provisional Directors of the Ottawa and Waddington Company will be held in Ottawa on Oct. 11, soon after which a meeting will be held in London, England.

A DESPATCH FROM FREDERICK, Md., dated Sept. 30, says: Civil Engineer Gill, of the Pennsylvania Railroad, will commence a survey of the new road between Frederick and Middletown next week. The road is to be equipped and operated by the Pennsylvania road.

THE MICHIGAN, INDIANA AND ST. LOUIS.—At length the Michigan, Indiana, and St. Louis Railroad has been located through Bourbon, and the contract let for the construction of the same. Work will commence at Bourbon, Ind., within the next thirty days.

THE Western North Carolina road is going ahead. On the line between Asheville and Ducktown 700 hands are employed in its construction. Twenty-four miles of the road, running as far as Waynesville, are completed and in running order. The line from Asheville to Ducktown is about 80 miles in length.

CHICAGO & ATLANTIC.—Fifty miles of steel remain to be laid on the Chicago & Atlantic road. The gap will be closed within a month, after which time the Erie expects to run through trains from Chicago to New York over its new line.

TRACTIVE FORCE FOR MOVING VEHICLES.—Some experiments have been made at Salem, Mass., to ascertain the tractive force requisite to move street cars and vehicles on a macadamized road. The apparatus used consisted of an inclined plane, at the upper end of which was an iron wheel, over which passed a rope. A loaded box-car, weighing, with its contents, 12,820 pounds, was drawn up the grade by a weight of 970 pounds suspended at the other end of the rope. A smaller car, weighing when empty 2,730 pounds, was occupied by fourteen persons, and drawn up by 939 pounds, and when unoccupied by 176 pounds. An ordinary load of sand on a macadamized road was started by 514 pounds, and an empty hack, weighing 1,550 pounds, by 196 pounds; the same hack, with four passengers inside, required 230 pounds to move it. On a level road, the load of sand was started by 240 pounds, while the large box car yielded to 56 pounds.

A NEW RAILROAD ENTERPRISE.—WESTCHESTER, Pa., September 29.—Those having the preliminary arrangements in hand for the building of the Delaware River, Phœnixville & Lancaster Railroad met in Phœnixville on Thursday, and took the necessary steps toward placing its construction under contract at once. Theo. Bertolet, a Phœnixville engineer, has been given the charge of looking after the line in Northern Chester County, and will in a few days have men employed upon it in giving the required grade.

RAILWAY CAR-SEAT RIGHTS.—There was quite a discussion in a railway car last night as to the right of an official of the train to remove the valise and coat of an occupant of a seat—a gentleman in attendance on the board meetings—who was then temporarily absent. He contended he had that right, while a learned judge, who was in the same car, on being appealed to, decided that the first occupant was entitled to his seat. On a railway train in Canada last week the claim of an occupant to a seat, whose baggage had been removed by an official to accommodate another person, was sustained, and it was returned and he resumed his seat.—*From the Portland (Me.) Press, Oct. 4.*

NEW ZEALAND NOTES.—WELLINGTON, September 7.—The New Zealand Parliament has passed bills authorizing loans to the extent of £4,000,000 for railways and public works, and has approved a resolution in favor of direct communication between England and New Zealand, with a subsidy of £20,000. Native affairs are quiet, and all the late difficulties are apparently ended.

THE NEW PEMIGEWASSET VALLEY ROAD.—Rail-laying on the new Pemigewasset Valley Railroad has been temporarily postponed, having reached Mad River, in Campton, about five miles north of the starting-point, on account of no bridge being yet built across it. Grading, ballasting, &c., are still progressing.

NEW RAILROAD ROUTE.—The engineers have commenced laying out the established route of a new road from Delmar to Cherrystone, Va.

CANALS.

THE NICARAGUA CANAL.—SAN FRANCISCO, Oct. 3.—The Oregon legislature has passed a joint resolution asking Congress to pass an act of incorporation of the Nicaragua Canal Company, which will be filed with the Secretary of State at Washington, for presentation to Congress next session.

CONTRACTS LET.

CHURCH CONTRACT LET.—The building committee of the Second Congregational Church of Holyoke, Mass., has awarded the contract for the new church to P. B. Johnson, of Palmer, for $50,300.

BRIDGE CONTRACT LET.—The Huntington *Commercial* says that the contract for building a bridge across the Ohio at Point Pleasant was given to the Keystone Bridge Company, of Pittsburgh, price $289,000. The bridge will be 1,400 feet in length, and must be completed in six months.

The bids for removing wreck and cargo of the government transport "Maple Leaf," from St. John's River, near Mandarin, Fla., were Samuel R. Cummings, N. Y., $14,250; J. A. Cloud & Co., New York, $4,890; R. S. Ross, of Fernandina, Fla., $3,800.

BUILDING.

CAMBRIDGE, Md., is to have a new $14,000 jail.

THE WISCONSIN CAPITOL.—The work upon the northern extension to the capitol at Madison is progressing with considerable more rapidity than that upon the south extension, the foundation for which is not yet entirely completed. The heavy iron joists for the first floor of the northern extension have all been placed in position, and the masons are now engaged upon the superstructure. The dressed stone-work is being pushed and the rough foundations are now nearly hidden by the wall which is outside of them.

MAKING FLOORS FIRE RESISTIVE.—Among the various plans now resorted to by English builders for rendering wooden flooring resistive to the action of fire is that of constructing solid timber floors, composed of ordinary joists placed close to each other, and spiked or screwed at intervals with bolts; the latter are fixed alternately, and, to form a key for the plastering, angular grooves are cut under each joist, these grooves forming a series of dove-tails. In a similiar manner, stairs are formed by a series of joists screwed or spiked together. With regard to partitions, preference is given by many to the French plan of constructing them with quarterings, filled in with rough stone rubble, then lathed on each side with strong laths, and a coat of plaster applied and pressed through the vacuities from each side. In the construction of roofs, the laying of solid concrete flats on iron joists, or iron joists fixed to the inclination of the roof, and then filled in with concrete on the French system, covered with asphalt, is a method highly approved.

LABOR.

LACK OF BRICKLAYERS IN CINCINNATI.—The demand for bricklayers in Cincinnati far exceeds the supply. This can probably be accounted for by the fact that all the buildings are being pushed in order that they may be got under roof before the winter sets in. The union price for bricklayers is $4.50 day, but some bosses are offering $5 per day. This will, no doubt, lead the men to strike for $5 all along the line on or before the first of next year, and this business will receive another setback. Cincinnati really needs about 100 more masons.

MISCELLANOUS.

TWO NEW CANADIAN PROVINCES.—OTTAWA, Ont., Oct. 4.—It is understood that the creation of two new provinces in the northwest has been decided upon by the government. One will be Qu'Appelle, with Regina as its capital and Mr. Dewdney as its Lieutenant-Governor. The other will be Saskatchewan, the capital for which has not yet been decided upon.

BIDS FOR BUILDING A RESERVOIR.

The following bids were received at the Department of Public Works, this city, on Oct. 2, for building a reservoir at Rye Ponds, in the towns of Harrison and North Castle, Westchester County:

NAMES OF CONTRACTORS.	125 acres grubbing and clearing.	1,000 cu. yds. rock excavation.	30,000 cu. yds. earth excavation.	15,000 cu. yds. embankment and rip rap.	50 cu. yds. concrete and stone masonry.	1,200 cu. yds. stone masonry.	200 cu. yds. concrete masonry.	2,300 cu. yds. dry stone wall.	45 m. ft. oak or chestnut plank and timber.	5,000 lin. ft. fence.	1,000 sq. yds. sodding.	1,700 lbs. wrought iron.	One 30 in. stop-cock and gearing.	50 lin. ft. 6-in. pipe.	175 lin. ft. 30-in. pipe.	TOTALS.
Sullivan & King	$25.00	$1.25	$0.32	$0.35	$18.00	$6.50	$5.00	$2.50	$40.00	$0.75	$0.30	$0.10	$150.00	$0.35 total	$1.25 total	$41,097.35
Dunn & Phelan	120.00	2.25	2.25	2.00	18.00	8.50	7.50	.06	100.00	1.10	.50	.20	500.00	200.00	1,000.00	140,028.00
John Satterlee	20.00	1.15	.24	.48	20.00	5.50	10.00	2.25	55.00	.45	.36	.05½	70.00	.55	1.50	38,388.80
L. P. Hendricks	3.50	.95	.28	.39	19.00	5.00	4.50	2.70	45.00	.70	.15	.08	175.00	.40	1.10	35,914.40
W. Phelan	15.00	1.25	.30	.30	22.00	5.50	5.00	2.00	7.50	1.50	.30	.08	100.00	.50	1.00	60,598.50

The proposal of L. P. Hendricks, being the lowest one received, was sent to the Department of Finance for examination and approval of sureties